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Recycling of oceanic lithosphere: Water, $f\text{O}_2$ and Fe-isotope constraints

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Spinel peridotite and garnet pyroxenite xenoliths from Hawaii provide important clues about the composition of the oceanic lithosphere, and can be used to assess its contribution to mantle heterogeneity upon recycling.

The peridotites have lower bulk H_2O (~70-114 ppm) than the MORB source, qualitatively consistent with melt depletion. The garnet pyroxenites (high pressure cumulates) have higher H_2O (200-460 ppm, up to 550 ppm accounting for phlogopite) and low $\text{H}_2\text{O}/\text{Ce}$ ratios (<100). The peridotites have relatively light Fe-isotopes ($\delta^{57}\text{Fe} = -0.34$ to 0.13) that decrease with increasing depletion, while the pyroxenites are significantly heavier ($\delta^{57}\text{Fe}$ up to 0.3). The observed xenolith, as well as MORB and OIB total Fe-isotope variability is larger than can be explained by existing melting models.

The high H_2O and low $\text{H}_2\text{O}/\text{Ce}$ ratios of pyroxenites are similar to estimates of EM-type OIB sources, while their heavy $\delta^{57}\text{Fe}$ are similar to some Society and Cook-Austral basalts. Therefore, recycling of mineralogically enriched oceanic lithosphere (i.e. pyroxenites) may contribute to OIB sources and mantle heterogeneity.

The $\text{Fe}^{3+}/\Sigma\text{Fe}$ systematics of these xenoliths also suggest that there might be lateral redox gradients within the lithosphere, between juxtaposed oxidized spinel peridotites ($\Delta\text{FMQ} = -0.7$ to 1.6, at 15 kb) and more reduced pyroxenites ($\Delta\text{FMQ} = -2$ to -0.4, at 20-25kb). Such mineralogically and compositionally imposed $f\text{O}_2$ gradients may generate local redox melting due to changes in fluid speciation (e.g. reduced fluids from pyroxenite encountering more oxidized peridotite). Formation of such incipient, small degree melts could further contribute to metasomatic features seen in peridotites, mantle heterogeneity, as well as the low velocity

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and high electrical conductivity structures near the base of the
lithosphere and upper mantle.